THE APPLICATION OF SOVEREIGN BOND SPREADS: THE CASE OF SELECTED EU COUNTRIES AND THE USA

[Využití výnosové křivky státních dluhopisů: případ vybraných zemí EU a USA]

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Abstract: The yield curve – specifically the spread between long term and short term interest rates is a valuable forecasting tool. It is simple to use and significantly outperform other financial and macroeconomic indicators in predicting recessions two to six quarters ahead. The steepness of the yield curve should be an excellent indicator of a possible future economic activity. A rise in the short rate tends to flatten the yield curve as well as to slow down real growth the near term. This paper aims to analyze the dependence between slope of the yield curve and an economic activity of selected EU countries and the USA between the years 2000 and 2014. The slope of the yield curve can be measured as the yield spread between sovereign 10-year bonds and sovereign 3-month bonds. The natural and probably the most popular measure of economic growth is GDP growth, taken quarterly. The results showed that the best predictive lags are lag of four and five quarters. The results presented also confirm that 10-year and 3-month yield spread has significant predictive power to real GDP growth after financial crisis. These findings can be beneficial for investors and provide further evidence of the potential usefulness of the yield curve spreads as indicators of the future economic activity.

Keywords: GDP prediction, slope, spread, yield curve.

JEL classification: E43, E44, E47, G01

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Introduction

The yield curve simply plots the yield of the bond against its time to maturity. Many market observes carefully track the yield curve's shape, which is typically upward sloping and convex. However when the yield curve becomes flat or slopes downward (the spread between sovereign 10-year and 3-month bond is negative) it may signal GDP decrease (recession).

The yield curve – specifically the spread between long term and short term interest rates is a valuable forecasting tool. It is simple to use and significantly outperform other financial and macroeconomic indicators in predicting recessions two to six quarters ahead.

Widespread use of the yield curve makes assessing its accuracy a worthwhile exercise for economists. But policymakers, too, need an accurate and timely predictor of future economic growth.

With sophisticated macroeconometric models and highly paid professional forecasters, is there any place for a simple indicator like the yield curve? Aside from the knowledge gained about the curve itself, there are several reasons to answer that question affirmatively. Simple predictions may serve as a check on more complex models, perhaps highlighting when assumptions or relationships need rethinking. Agreement between predictions increases confidence in the results, while disagreement signals the need for a second look. A simple, popular indicator also provides some insight into market sentiment. It is always a good idea to

check whether the expensive and complicated forecasts actually do perform better. After first reviewing some basics about the yield curve and the reasons it might predict future growth, we look at the actual relationship (Haubrich and Dombrosky, 1996).

This paper builds on a wide range of previous researches, but differs in some ways. Bernard and Gerlach (1998) in their paper showed empirically on eight countries that the slope of the yield curve is a good predictor of the real economic activity. Berk and van Bergeijk (2001) examined 12 euro-area countries over the period of 1970-1998 and found that the term spread contains only limited information about future output growth. Their work is based on the previous theoretical researches of Estrella and Hardouvelis (1991), Estrella and Mishkin (1996). There was proven the evidence that the slope of the yield curve and the future GDP activity are related together. However it is necessary to say that this rule was true until the end of 20th century and it mostly disappeared at the beginning of 21st century and appeared again during the financial crisis (from 2008) and later on (De Pace, 2011; Giacomini and Rossi, 2006; Chinn and Kucko, 2010). Most of the studies are focused on the relationship of the yield curve and GDP activity of the United States of America.

The aim of this paper is to show if the yield spread possesses the predictive power of future economic activity in selected EU countries and the USA and to examine which time lag of the spread is the best for prediction of the future GDP.

Despite various researches, there is not any comprehensive theory that would prove the correlation between the yield spread and economic development of the country yet. We often come across the statements that have only theoretical basis without generally valid empirical evidence. Economic models are largely based on the argument that the yield curve tends to be flatter in the situation of the tight monetary policy and the economic slowdown typically occurs with a slight time lag (Szarowská, 2013).

Almost perfect tool containing the relevant future data provides the yield spread of government bonds. The simplest interpretation of the yield spread is through monetary policy of the country. Based on this criterion - relatively low spread reflects the restrictive and tight monetary policy and vice versa - high spread reflects loose monetary policy. We can find the theoretical justification for using of the spread in expectations hypothesis. It assumes that a long term rate of return is the average of the current and expected future short term yields. The investor's decision to invest in short term or long term asset is completely irrelevant (Mishkin, 1990).

Dependence of the yield spread and GDP can be derived from their connection to the monetary policy of the state. As bond yields react to monetary policy as well as monetary policy is able to respond to the output of the economy, the yield curve assumes overlapping of policy measures and responses. The yield curve has the ability to reflect future production either directly or indirectly. Indirectly it comes to predicting of the future interest rate and the future monetary policy. It may also reflect the future production directly because the 10-year yields may depend on estimates of the output of the economy in 10 years.

A question arises – how many months, quarters, years of future economic activity can be predicted by the yield spread? Based on the study of Bonser-Neal and Morley (1997) as well as Chinn and Kucko (2010) spread has the greatest ability in predicting one-year horizon (four quarters ahead). As it was mentioned above, to prove if the spread has the best predictive power in one-year horizon is one of the aims of this paper.

1 Methodology and data

There are many ways of using the yield curve to predict the future real activity. One common method uses inversions (when short term rates are higher than long term rates) as recession indicators. Obtaining predictions from the yield curve requires a lot of preliminary work. There is the principle which needs to be held: keep the process as simple as possible.

A yield curve may be flat, up-sloping, down-sloping or humped. The standard solution uses a spread (difference between two rates). The problem is to choose the spread between the right terms. The most used spread is between 10-year and 3-month bonds. The problem is that there are rarely bonds which mature exactly in 10 years (or 3 months). In that case the best solution is to use the yield curve, which shows the yield of each maturity. Creating and calculating of the yield curve is a rather difficult task because there are many ways how to do it and every country uses a different model of construction.

The yield curves are constructed by Bloomberg, therefore the data for spreads were gained from Bloomberg. For the spreads 10-year government bond rates minus 3-month sovereign bond rates were chosen (Estrella and Hardouvelis, 1991; Estrella and Mishkin, 1996). Quarterly data were used for the spreads because the data of the economic activity are taken on quarterly basis as well. The data of real GDP can be found at Eurostat, OECD statistics or Bloomberg. The data of real GDP obtained and used in this paper are from OECD statistics.

The selected countries are countries of EU-28 (Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, the United Kingdom) and the USA. Unfortunately there were no data for Croatia, Cyprus, Estonia, Latvia, Lithuania and Romania available, therefore we had to omit these countries. The dataset of Malta was available only from 3Q2008 to 3Q2014.

There is no previous research which would prove or reject the hypothesis of real GDP and bond spread dependence in European countries.

As a measure of real growth four-quarter percent change in real GDP was used (thus the percent change of the quarter against the last year's same quarter was calculated, e.g. the change from 1Q2004 and 1Q2003 real GDP was used). GDP is standard measure of aggregate economic activity and the four-quarter horizon answers the frequently asked question – what happens the next year?

The sample period starts from 1Q2000 and ends on 3Q2014. This time range covers the period before financial crisis, period of financial crisis and period after financial crisis. The basic model is designed to predict real GDP growth/decrease two to six quarters into the future based on the current yield spread (Bonser-Neal and Morley, 1997).

This was accomplished by running of a series of regressions using real GDP activity and the spread between 10-year and 3-month bond yields lagged two to six quarters (e.g. if the spread was lagged by 4 quarters, the interest rate spread used for 3Q2001 is actually from 3Q2000).
The last step is to find out which spread lag is the best for which country and to prove the hypothesis that the lag of four quarters is the best one for prediction of future GDP growth.

To generate the GDP predictions the regression using the whole sample was run, and later on two divided samples of real GDP and spreads of each selected country (the sample is divided in 4Q2007/1Q2008, because this period preceded financial crisis and should show some changes in prediction of the yield curve spread) were run.

The coefficients α and β were estimated for each country:

$$Real\ GDP_{t+n} = \propto + \beta * spread_t + \varepsilon_t \quad (1)$$

Where:
$Real\ GDPt + n$ is a prediction of the future real GDP in time $t + n$
n is the lag of spread, value of the lag can be 2, 3, 4, 5 or 6
$spread_t$is spread between 10-year and 3-month state bonds in time t
ε_t is a white noise

2 Results and discussion

The whole sample of dataset contains the real GDP from 1Q2000 to 3Q2014. A regression of the whole sample was run and we got the results as seen in Table 1.

Table 1: Results of all countries and whole sample from OLS regression

1Q00 – 3Q14	Constant	Spread	P – value (F – test)	R^2
Austria n=5	0.00392699	0.835224	0.0021 ***	0.153549
Belgium n=4	0.00892386	0.253578	0.2992	0.018896
Bulgaria n=6	0.0186799	0.628145	0.0018 ***	0.158618
Czech Rep. n=2	0.0339965	-0.347492	0.5145	0.007493
Denmark n=4	-0.0079170	1.17141	0.0016 ***	0.161495
Finland n=5	-0.0099475	1.93101	0.0001 ***	0.227732
France n=5	0.00427149	0.442720	0.0834	0.051648
Germany n=5	-0.0037077	1.08377	0.0059 ***	0.125750
Greece n=2	0.0494464	-0.595524	2.62e-08 ***	0.421816
Hungary n=6	0.0129305	-0.776075	8.13e-05 ***	0.240243
Ireland n=2	0.0335926	-0.350539	0.1010	0.046483
Italy n=2	0.0192736	-0.748919	0.0024 ***	0.150165
Luxembourg n=6	0.0279051	0.703821	0.1433	0.037197
Malta n=4	-0.0106991	1.27180	0.0217 **	0.208677
Netherlands n=2	0.0331701	-1.32837	1.11e-05 ***	0.289354
Poland n=4	0.0379799	0.243271	0.0043 ***	0.134113
Portugal n=2	0.0134541	-0.423174	0.0149 **	0.099645
Slovakia n=2	0.0598837	-1.49028	8.77e-05 ***	0.238328
Slovenia n=2	0.0312604	-0.776240	0.0524	0.064425
Spain n=2	0.0379462	-1.09437	3.75e-07 ***	0.366670
Sweden n=4	-0.0132704	2.51857	4.64e-012 ***	0.570886
United Kingdom n=5	0.00283286	0.741750	0.0830	0.051806
USA n=6	0.00939793	0.575424	0.0029 ***	0.145038

Source: author's own calculation in Gretl, data of government bond spreads obtained from terminal Bloomberg, data of real GDP obtained from OECD statistics

Surprisingly we got the best results of the models mostly for lag of spreads 2 (Greece, Italy, the Netherlands, Portugal, Slovakia, Spain). The lag of spreads 4 is the second best choice (Denmark, Malta, Poland, Sweden). And the third best was the lag of spreads 5 (Austria, Finland, Germany).

We can say that models for Austria, Bulgaria, Denmark, Finland, Germany, Greece, Hungary, Italy, Malta, the Netherlands, Poland, Portugal, Slovakia, Spain, Sweden and the USA are statistically significant, because the p-values are under 1% (***) or 5% (**), however the R^2 are not very high except of Finland, Greece, Hungary, Malta, the Netherlands, Slovakia, Spain and Sweden.

The R^2 coefficients (coefficients of determination) show us how many percent of the sample can be explained by these models.

Models for countries mentioned above may be used as predictive models.

The model for Belgium, the Czech Republic, France, Ireland, Luxembourg, Slovenia and the United Kingdom cannot be used as predictive due to their high p-value and very low R^2.

For example we can say that future real GDP of Austria will be:

$$\text{Real GDP}_{\text{Austria t+5}} = -0.00392699 + 0.835224 * \text{spread}_{\text{Austria t}}$$

By this model we can predict future real gross domestic product for Austria five quarters ahead.

We can test the hypothesis that the behavior of the spread and gross domestic product has changed during the financial crisis, therefore the sample was divided into two samples in order to prove this hypothesis.

2.1 Results of regression – divided samples

The research continued as follows – the whole sample was divided into two samples. The first one is from 1Q2000 to 4Q2007, the second one is from 1Q2008 to 3Q2014 in order to show if there is any change of behavior and dependency between the variables before or after the financial crisis.

Regressions of the first sample and the second sample were run. The results for the time span of 1Q2000 – 4Q2007 (first sample) are possible to see in Table 2, the results for the period of 1Q2008 – 3Q2014 (second sample) are in Table 3.

In the first period the best results were gained with lag of spreads by 6 quarters (Austria, Finland, Hungary, Italy, the Netherlands, Portugal, Slovenia and the USA). The second best results we got for the lag of spreads by 4 quarters (Denmark, Greece, Ireland, Luxembourg, Slovakia).

We can say that the models for Belgium, Bulgaria, the Czech Republic, Denmark, Greece, Hungary, Ireland, Luxembourg, the Netherlands, Poland, Slovakia, Slovenia, Spain, Sweden, the United Kingdom and the USA may be used as predictive, because their p-value is under 5% (**).

Again the R^2 are not very high except for Bulgaria, the Czech Republic, Greece, Hungary, Poland, Spain, Sweden and the USA.
Models for Austria, Finland, France, Germany, Italy and Portugal cannot be used as predictive models, because of their high p-values and very low R^2.

Table 2: Results of all countries and sample from 1Q2000 to 4Q2007

1Q00 – 4Q07	**Constant**	**Spread**	**P – value (F – test)**	**R^2**
Austria n=6	0.0307787	-0.455781	0.1763	0.060084
Belgium n=3	0.00940078	0.789470	0.0171 **	0.175160
Bulgaria n=2	0.0675536	-0.382749	0.0023 ***	0.269139
Czech Rep. n=5	0.0185649	1.83205	2.76e-05 ***	0.448581
Denmark n=4	0.00896117	0.686048	0.054216 **	0.118022
Finland n=6	0.0402452	-0.361997	0.4042	0.023303
France n=3	0.0132341	0.512490	0.0610	0.112158
Germany n=2	0.0258136	-0.714181	0.1058	0.084827
Greece n=4	0.0824349	-0.944996	0.000900 ***	0.311635
Hungary n=6	0.0218873	-0.70094	1.88e-06 ***	0.536513
Ireland n=4	0.0362481	1.06149	0.033029**	0.142717
Italy n=6	0.0193113	-0.365716	0.2460	0.044581
Luxembourg n=4	0.0414236	0.727023	0.050328 **	0.121733
Malta	x	x	x	x
Netherlands n=6	0.0140177	0.452712	0.0405 **	0.132546
Poland n=5	0.0514526	0.474488	2.06e-06 ***	0.533742
Portugal n=6	0.0268181	-0.793569	0.0684	0.106410
Slovakia n=4	0.0670920	-1.35016	0.0093 ***	0.204940
Slovenia n=6	0.0518221	-0.652960	0.0303 **	0.147055
Spain n=2	0.0409743	-0.608141	0.0004 ***	0.341136
Sweden n=3	0.0127549	1.24421	0.0005 ***	0.339790
United Kingdom n=3	0.0217436	0.513701	0.0118 **	0.193272
USA n=6	0.0179499	0.535402	0.0015 ***	0.289367

Source: author's own calculation in Gretl, data of government bond spreads obtained from terminal Bloomberg, data of real GDP obtained from OECD statistics

In the second period the best results were gained by lag of spreads by 5 quarters, the second best results we got with the lag of 4 quarters. All models except for the models for the Netherlands, Portugal, Slovakia, Slovenia and Spain can be used as predictive and we got much better results from most of the countries. R^2 of Austria, Denmark, Finland, France, Germany and Sweden are higher than 40% which is very good.

This change in prediction possibility may be caused by different behavior of financial markets after the financial crisis (after year 2008).

Table 3: Results of all countries and sample from 1Q2008 to 4Q2013

1Q08 – 4Q13	Constant	Spread	P – value (F – test)	R^2
Austria n=5	-0.013	1.23265	9.07e-05 ***	0.464523
Belgium n=4	-0.01277	0.745299	0.0195 **	0.199633
Bulgaria n=6	-0.0062487	0.933633	0.0162 **	0.20992
Czech Rep. n=4	-0.02387	1.27710	0.0366 **	0.163226
Denmark n=5	-0.03315	2.09861	0.0002 ***	0.442244
Finland n=5	-0.04071	2.55453	2.57e-05 ***	0.514106
France n=5	-0.02207	1.16414	0.0001 ***	0.452340
Germany n=5	-0.03102	2.30405	0.0002 ***	0.439579
Greece n=2	0.0002547	-0.335482	0.0008 ***	0.369159
Hungary n=2	-0.01589	1.25960	0.0213 **	0.194432
Ireland n=4	-0.02888	0.612569	0.0047 ***	0.277797
Italy n=5	-0.03444	0.745154	0.0172 **	0.206746
Luxembourg n=3	0.00111139	3.13188	0.0059 ***	0.265790
Malta n=4	-0.0106991	1.27180	0.0217 **	0.208677
Netherlands n=5	-0.0118355	0.544089	0.2048	0.063495
Poland n=4	0.0192019	1.00260	0.0044 ***	0.282251
Portugal n=5	-0.0198834	0.389921	0.0620	0.132423
Slovakia n=4	-0.0004261	0.991022	0.1014	0.103730
Slovenia n=5	-0.0180976	0.796055	0.1592	0.077671
Spain n=6	-0.0159121	0.330497	0.1353	0.086996
Sweden n=4	-0.0225111	2.75388	2.61e-07 ***	0.660520
United Kingdom n=5	-0.0268710	1.34084	0.0397 **	0.158473
USA n=6	-0.0061863	0.885591	0.0080 ***	0.249557

Source: author's own calculation in Gretl, data of government bond spreads obtained from terminal Bloomberg, data of real GDP obtained from OECD statistics

The best predictive models are as follows:

$$\text{Real GDP}_{\text{Austria t+5}} = -0.013 + 1.23265 * \text{spread}_{\text{Austria t}}$$

$$\text{Real GDP}_{\text{Belgium t+4}} = -0.01277 + 0.745299 * \text{spread}_{\text{Belgium t}}$$

$$\text{Real GDP}_{\text{Bulgaria t+6}} = -0.0062487 + 0.933633 * \text{spread}_{\text{Bulgaria t}}$$

$$\text{Real GDP}_{\text{Czech Republic t+4}} = -0.02387 + 1.27710 * \text{spread}_{\text{Cezech Republic t}}$$

$$\text{Real GDP}_{\text{Denmark t+5}} = -0.03315 + 2.09861 * \text{spread}_{\text{Denmark t}}$$

$$\text{Real GDP}_{\text{Finland t+5}} = -0.04071 + 2.55453 * \text{spread}_{\text{Finland t}}$$

$$\text{Real GDP}_{\text{France t+5}} = -0.02207 + 1.16414 * \text{spread}_{\text{France t}}$$

$$\text{Real GDP}_{\text{Germany t+5}} = -0.03102 + 2.30405 * \text{spread}_{\text{Germany t}}$$

$$\text{Real GDP}_{\text{Greece t+2}} = 0.0494464 + -0.595524 * \text{spread}_{\text{Greece t}}$$

$$\text{Real GDP}_{\text{Hungary t+6}} = 0.0129305 + 1.25960 * \text{spread}_{\text{Bulgaria t}}$$

$$\text{Real GDP}_{\text{Ireland t+4}} = -0.02888 + 0.612569 * \text{spread}_{\text{Ireland t}}$$

$$\text{Real GDP}_{\text{Italy t+5}} = -0.03444 + 0.745154 * \text{spread}_{\text{Italy t}}$$

$$\text{Real GDP}_{\text{Luxembourg t+3}} = 0.00111139 + 3.13188 * \text{spread}_{\text{Luxembourg t}}$$

$$\text{Real GDP}_{\text{Malta t+4}} = -0.0106991 + 1.27180 * \text{spread}_{\text{Malta t}}$$

$$\text{Real GDP}_{\text{Netherlands t+2}} = 0.0331701 - 1.32837 * \text{spread}_{\text{Netherlands t}}$$

$$\text{Real GDP}_{\text{Poland t+4}} = 0.0192019 + 1.00260 * \text{spread}_{\text{Poland t}}$$

$$\text{Real GDP}_{\text{Portugal t+2}} = 0.0134541 + -0.423174 * \text{spread}_{\text{Portugal t}}$$

$$\text{Real GDP}_{\text{Slovakia t+2}} = 0.0598837 - 1.49028 * \text{spread}_{\text{Slovakia t}}$$

$$\text{Real GDP}_{\text{Spain t+2}} = 0.0379462 - 1.09437 * \text{spread}_{\text{Spain t}}$$

$$\text{Real GDP}_{\text{Sweden t+4}} = -0.0225111 + 2.75388 * \text{spread}_{\text{Sweden t}}$$

$$\text{Real GDP}_{\text{United Kingfom t+5}} = -0.0268710 + 1.34084 * \text{spread}_{\text{United Kingdom t}}$$

$$\text{Real GDP}_{\text{USA t+6}} = -0.0061863 + 0.885591 * \text{spread}_{\text{USA t}}$$

For example if there would be a change of 1% up in the spread of Austria then the GDP would increase about 1.123% ($-0.013 + 1.123265 * 1\%$).

The best model for Greece, Hungary, the Netherlands, Portugal and Slovakia – are taken from the whole sample (1Q2000 – 3Q2014). All the other models are taken from the divided sample (1Q2008 – 3Q2014).

At the end we can summarize the findings and predict the future GDP of the selected countries.

2.2 Prediction of GDP growth

The spreads are known from the year 2014. The predictions of GDP growth are in Table 4.

The GDP of Austria, Belgium, the Czech Republic, Finland, France, Germany and the United Kingdom should rise and later on decrease. The GDP of Bulgaria, Greece, Hungary, Luxembourg, Malta, the Netherlands, Poland, Slovakia, Sweden and the United States should rise in the observed periods. The GDP of Ireland, Italy and Portugal should decrease. The GDP of Spain should decrease and later on increase.

Table 4: Prediction of GDP growth in the selected countries

	4Q2014	1Q2015	2Q2015	3Q2015	4Q2015	1Q2016
AUS spread	0.02052	0.01612	0.01517	0.01176	0.00668	
AUS GDP	0.012294	0.0068703	0.0057	0.001496	-0.004766	
BEL spread	0.02497	0.02024	0.01696	0.01255		
BEL GDP	0.00584	0.0023149	-0.0001	-0.003416		
BUL spread	0.029471	0.030021	0.02715	0.028811	0.030472	0.032133
BUL GDP	0.021266	0.0217799	0.0191	0.0206502	0.022201	0.0237517
CZE spread	0.024335	0.021245	0.0136	0.011263		
CZE GDP	0.007208	0.003262	-0.0065	-0.009486		
DEN spread	0.01975	0.01619	0.01618	0.01149	0.00929	
DEN GDP	0.008298	0.0008265	0.00081	-0.009037	-0.013654	
FIN spread	0.01979	0.0171	0.01398	0.01111	0.00637	
FIN GDP	0.009844	0.0029725	-0.005	-0.012329	-0.024438	
FRA spread	0.024127	0.018947	0.01677	0.01315	0.008786	
FRA GDP	0.006017	-1.3E-05	-0.0026	-0.006762	-0.011842	
GER spread	0.01844	0.01519	0.01276	0.01038	0.00705	
GER GDP	0.011467	0.0039785	-0.0016	-0.007104	-0.014776	
GREECE spread	0.06499	0.04191				
GREECE GDP	0.010743	0.024488				
HUN spread	0.027	0.0275	0.0215	0.0327	0.0207	0.0126
HUN GDP	0.046402	0.0470321	0.03947	0.053582	0.038467	0.028264
IRE spread	0.03295	0.02622	0.02143	0.01592		
IRE GDP	-0.0087	-0.012818	-0.0158	-0.019128		
ITA spread	0.03483	0.02877	0.02662	0.02225	0.01776	
ITA GDP	-0.00849	-0.013002	-0.0146	-0.01786	-0.021206	
LUX spread	0.0208	0.0191	0.0157			
LUX GDP	0.066254	0.0609303	0.05028			
MAL spread	0.02935	0.02754	0.02513	0.0216		
MAL GDP	0.026628	0.0243263	0.02126	0.0167718		
NET spread	0.02234	0.01792				
NET GDP	0.003494	0.0093657				
POL spread	0.020748	0.017875	0.01125	0.011431		
POL GDP	0.040004	0.0371234	0.03048	0.0306626		
POR spread	0.046857	0.044252				
POR GDP	-0.00637	-0.005272				
SK spread	0.020666	0.018661				
SK GDP	0.029086	0.0320736				
SPA spread	0.03523	0.02906				
SPA GDP	-0.00061	0.0061438				
SWE spread	0.01764	0.01368	0.01288	0.01298		
SWE GDP	0.026067	0.015162	0.01296	0.0132343		
UK spread	0.02672	0.02295	0.02232	0.01953	0.01292	
UK GDP	0.008956	0.0039013	0.00306	-0.000684	-0.009547	
USA spread	0.029623	0.026876	0.0251	0.024736	0.021357	0.018069
USA GDP	0.020048	0.0176148	0.01604	0.0157197	0.012727	0.0098154

Source: author's own calculation, data of government bond spreads obtained from terminal Bloomberg, data of real GDP obtained from OECD statistics

At the end we can summarize the new theoretical finding according to which lag of spread is the best for predicting of the future GDP. We proved that in these selected countries the best lag of spreads are lag 4 and lag 5. These lags show the best results in the models of the divided period – after financial crisis. The results show that the dividing of the sample made a difference between pre-crisis and after-crisis period and it showed bigger influence of spreads on predicting of the future GDP. The finding that the best lags of spreads are four and five confirm the theoretical background which says that the lag of four quarter is the best for the GDP prediction in the United States of America (from 1970 to 2000).

Conclusions

Does the yield curve accurately predict the real economic growth? Answering this seemingly simple question requires a surprising amount of preliminary work. The 10-year - 3-month spread has substantial predictive power and should provide good forecast of real growth two to six quarters into the future. We showed that the best predictive lags of spreads are lags of four and five quarters in order to get the best results for predictive models. The results presented above confirm that 10-year and 3-month yield spread has a significant predictive power for real GDP growth and the behavior of the models changed during and after the financial crisis. The results show that the dividing of the sample made a difference between pre-crisis and after-crisis period and it showed bigger influence of spreads on predicting of the future GDP.

The simple yield curve growth forecast should not serve as a replacement for the predictions of companies, which deal with predicting of many economic indicators, it however does provide enough information to serve as a useful check on the more sophisticated forecasts.

Future research could be extended to a wider examination of the best lags of spreads in more countries around the world. It would be interesting to see if there is any rule which would prove the hypothesis that lag of four and five quarters is the best for predicting future GDP growth in the countries out of the European Union (it was empirically proved that in the USA during 1970 and 2000 the best lag of spread was a lag of 4 quarters).

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